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Current and future role of magnetically assisted gastric capsule endoscopy in the upper gastrointestinal tract

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***Abstract*:** Capsule endoscopy first captivated the medical world when it provided a means to visualize the small bowel, which was previously out of endoscopic reach. In the subsequent decade and a half we continue to learn of the true potential that capsule endoscopy has to offer. Of particular current interest is whether capsule endoscopy has any reliable investigative role in the upper gastrointestinal tract. Much research has already been dedicated to enhancing the diagnostic and indeed therapeutic properties of capsule endoscopy. Specific modifications to tackle the challenges of the gut have already been described in the current literature. In the upper gastrointestinal tract, the capacious anatomy of the stomach represents one of many challenges that capsule endoscopy must overcome. One solution to improving diagnostic yield is to utilize external magnetic steering of a magnetically receptive capsule endoscope. Notionally this would provide a navigation system to direct the capsule to different areas of the stomach and allow complete gastric mucosal examination. To date, several studies have presented promising data to support the feasibility of this endeavour. However the jury is still out as to whether this system will surpass conventional gastroscopy, which remains the gold standard diagnostic tool in the foregut. Nevertheless, a minimally invasive and patient-friendly alternative to gastroscopy remains irresistibly appealing, warranting further studies to test the potential of magnetically assisted capsule endoscopy. In this article the authors would like to share the current state of magnetically assisted capsule endoscopy and anticipate what is yet to come.

Keywords: capsule endoscopy, magnetic, stomach, oesophagus, gastrointestinal, MACE, MGCE

Background

Capsule endoscopy has come a long way since its conceptualization and all-inspiring entrance to the world of medicine in the year 2000 [Iddan *et al.* 2000]. Conceived for the purpose of small bowel visualization it is now considered both deep-rooted and reliable. Moreover, the natural attraction to a minimally invasive and patient-friendly method of investigating the gastrointestinal tract is undeniable [Bouchard *et al.* 2014]. As a consequence, much effort has been made to expand the role of capsule endoscopy to pan-enteric territory [Hale and McAlindon, 2014; Hosoe *et al.* 2015]. Capsules specifically designed for the oesophagus and lower gastrointestinal tract are now in commercial use [Ladas *et al.* 2010; Spada *et al.* 2012]. Yet capsule endoscopy remains the underdog patiently waiting to prove its worth against conventional endoscopy in the upper and lower gastrointestinal arenas. In the upper gastrointestinal tract it is largely hindered by the capacious and irregular anatomy of the stomach. Peristaltic waves and a collapsed stomach, unlike the distended mucosal views during conventional gastroscopy, add to the difficulties that capsule endoscopy must overcome to adequately assess the gastric mucosal surface [Rahman *et al.* 2015a]. If capsule endoscopy is to be accepted as comparable with conventional oesophagoduodenoscopy (OGD) it must first prioritize in demonstrating reliable and complete mucosal visualization.

Current commercially available capsules lack the ability to resolve many of the aforementioned environmental constraints of the stomach,

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primarily because of passive locomotion. Significant interest has thus been placed onto both internal and external actuation methods to generate active locomotion and free manoeuvrability [Ciuti *et al.* 2011; Koulaouzidis *et al.* 2015]. The authors herein have chosen to focus on the promising field of magnetic external actuation. To explore the internal actuation models available to date would demand a much lengthier review and has been previously described by other authors in excellent fashion [Koulaouzidis *et al.* 2015]. Magnetic manipulation of capsule endoscopes was first described in 2006 [Carpi *et al.* 2006]. A cascade of technological adaptations has subsequently followed, exploiting this technique. Herewith we describe the recent advances in magnetic assisted capsule endoscopy (MACE).

Hand-held magnetic manipulation

In 2010, Swain and colleagues first demonstrated magnetic manoeuvrability in a human oesophagus and stomach [Swain *et al.* 2010]. In this single case study, a volunteer was given a modified wireless capsule endoscope to swallow. The model for this prototype was based on the PillCam COLON capsule (Given Imaging Ltd, Yoqneam, Israel). Modifications utilized magnetic material to allow for external magnetic manipulation while maintaining the capacity to capture and transmit images. In order to achieve this, the standard on/off magnetic reed switch was replaced for a thermal switch, activated by submersing the capsule in hot water at 60°. The modifications however necessitated internal space, hence the image-capturing rate was fixed at four frames per second from a single imager rather than dual sensors. In conjunction with this capsule there was a real-time imager (Given Imaging Ltd) and an external rectangular paddle-like magnet, specifically constructed for this study. Concomitant gastroscopy was performed to assess capsule movements in real time. The group reported excellent manoeuvrability of the capsule but also volunteered the possibility of such effortless manipulation due to the artificial gaseous distension from the gastroscope. In time this has proven true and subsequent studies have failed to reproduce such ease of manipulation against a collapsed and peristalsing stomach.

Keller and colleagues later that year published two further studies on healthy volunteers [Keller *et al.* 2010, 2011]. The first study demonstrated the feasibility of magnetic control of a capsule endoscope in the oesophagus [Keller *et al.* 2010]. It compared the Pillcam ESO2 (Given Imaging Ltd), designed to examine the oesophagus, with a modified version of the Pillcam COLON (Given Imaging Ltd). The modified Pillcam COLON capsule was similar to that used in the study performed by Swain and colleagues [Swain *et al.* 2010] and was customized to allow manipulation by an external magnet paddle. Although external manipulation of the capsule was achievable, the authors were unable to consistently reproduce somersault movements of the capsule within the oesophagus, as compared with their previous study [Swain *et al.* 2010]. Furthermore, the magnetic forces did not achieve translocation movements up and down the oesophagus. The feasibility of external magnetic capsule actuation, however, was still successfully demonstrated.

In their follow up study Keller and colleagues demonstrated the feasibility of magnetic manoeuvring of a modified capsule endoscope within the stomach [Keller *et al.* 2011]. The group reported excellent manoeuvrability in seven of the ten volunteers. Visualisation of the mucosa was variable however, with seven of the subjects having high visualization (varying from 75% to 90% of the mucosa being inspected) and the remainder having moderate visualization (varying from 50% to 60% mucosal visualisation). From this early study, several obstacles were identified. First, increasing distances between the external magnetic source and the capsule exponentially reduced the response to magnetic manipulation; such that patients with a higher body mass index and a thicker abdominal wall imposed a challenge. Second, it would appear that the magnetic force was also insufficient to withstand the peristaltic forces from a migrating motor complex propelling a capsule from the antrum into the duodenum. Lastly, mucosal views were obscured in part by the collapsed state of the stomach, if not by opaque gastric contents. Herein lie some of the main limitations of MACE that constrain its diagnostic potential currently. Despite this, all three studies demonstrated excellent tolerability to MACE, meriting further research into this patient-friendly endoscopic alternative [Keller *et al.* 2010, 2011; Swain *et al.* 2010].

Intromedic Ltd (Seoul, South Korea) have developed the MiroCam-Navi (Figure 1). This utilizes the standard MiroCam small bowel capsule, modified with a magnetic inclusion body for magnetic steering in the upper gastrointestinal tract.

The steering is controlled by an external hammer-like hand-held permanent magnet and the images can be directed from the sensor belt on the patient to a real-time view software via Wi-Fi. A recent study by Rahman and colleagues demonstrated the effectiveness of the MiroCam-Navi system in 26 human volunteers for the first time [Rahman *et al.* 2015c]. Following a 12-hour fast, volunteers were given water containing metoclopramide, pronase and simethicone for prokinetic, mucolytic and antifoaming effects, respectively. This was followed by MACE examination. They then proceeded to a standard OGD within 3 days of MACE. In their study, Rahman and colleagues successfully reported visualization at each major landmark within the upper gastrointestinal tract in 88% to 100% of cases (oesophagogastric junction, 92%; cardia, 88%; fundus, 96%; body, 100%; incisura, 96%; antrum, 96%; and pylorus, 100%). Of note, however, the Z-line was only visualized in 46% of cases and the authors reported difficulty in overcoming the speed at which the capsule entered the stomach. Obstacles reported from this study resonate with the aforementioned feasibility studies. Reliable manipulation of the capsule within the stomach in this case was particularly troublesome in the proximal stomach secondary to the distance from the skin surface through which magnetic forces would have to transverse. In contrast, the authors reported that obstruction from rugal folds could, in the majority of cases, be overcome by distension from additional water ingestion. Opaque gastric contents were also culpable for reducing mucosal visualization. Granted in a relatively small cohort of volunteers, there was a positive concordance for eight of nine minor pathological findings when compared with standard gastroscopy. This mirrors preceding *ex vivo* studies on MACE with the MiroCam-Navi system; Hale and colleagues demonstrated that the MiroCam-Navi had detection rates comparable to flexible endoscopy in identifying beads sewn onto the mucosal surface of *ex vivo* porcine stomachs [Hale *et al.* 2015].

Robot-assisted magnetic manipulation: Olympus and Siemens

Hand-held magnets have attractive properties being simple to use and relatively inexpensive. However, Ciuiti and colleagues have demonstrated in porcine models that robotic control is superior in movement precision when compared to manual operation [Ciuti *et al.* 2010]. Pertaining to this, Rey and colleagues and Denzer and coworkers led a trilogy of studies in France using a novel MACE system [Rey *et al.* 2010, 2012; Denzer *et al.* 2015].

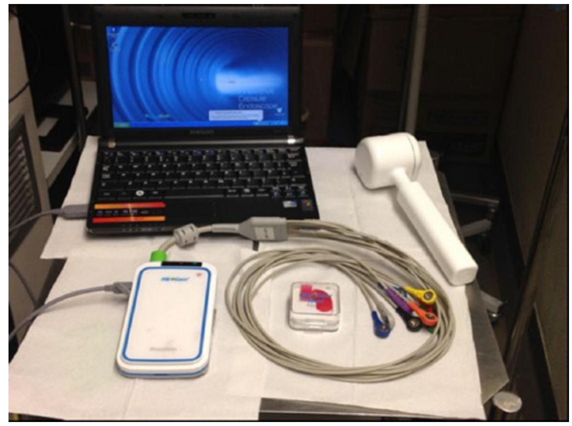

Figure 1. The Mirocam-Navi system.

The first feasibility study by Rey and colleagues in 2010 introduced the joint creation between Olympus Medical Systems Corporation and Siemens Healthcare [Rey *et al.* 2010]. An Olympus magnetically responsive capsule endoscope was paired with a Siemens magnetic navigation system (Figure 2). This was in the form of equipment akin in appearance to a magnetic resonance imaging (MRI) machine but with magnetic forces significantly less when manoeuvring the capsule endoscope (150–500 times less than a conventional MRI scanner). The capsule endoscope contained two image sensors which relayed images real-time to a screen accessible to the physician. It contained magnetic material in order to render it susceptible to magnetic manipulation. With the precision of magnetic steering by two joysticks, the physician was able to achieve five degrees of freedom of motion in three dimensions. This included translocation in the x, y and z axes in addition to tilting and rotational movements.

A total of 29 volunteers and 24 patients were recruited to undergo MACE 24 hours after gastroscopy. Following ingestion of 1300 ml of water MACE was performed. Additional patient positional change was introduced in order to facilitate steering of the capsule endoscope whenever necessary. The visualisation of landmarks was effective in the distal stomach (96%, gastric pylorus; 98%, antrum; 96%, gastric body) but in comparison, results were not as successful in proximal

Figure 2. Olympus and Siemens magnetically assisted capsule endoscopy system. (Reprinted with permission from Rey *et al.* [2012].)

regions (73%, fundus; 75%, cardia). This was accounted for by the collapsed state of the proximal stomach, obstructing mucosal views. Residual gastric mucus and debris was mostly overcome by additional water ingestion, but in three cases there was resistant mucus despite efforts to resolve impaired visualization. Mucosal views were also impaired in two cases by rapid, uncontrolled, transpyloric capsule translocation.

Several fruitful findings were extracted from the first trial of this series. Gastric visualization was achieved by MACE, particularly of good quality in the distal stomach. In addition it demonstrated the safety of the Olympus/Siemens system. Only one patient had transient abdominal pain which spontaneously resolved while another experienced abdominal pain which was later diagnosed as recurrent diverticulitis; otherwise there were no adverse effects with MACE or the volume of water that patients ingested. Although unblinded by design, of the 30 pathological findings detected across both modalities, concordance between MACE and gastroscopy was seen in 14 lesions. Six additional lesions were identified by gastroscopy alone, but intriguingly ten additional lesions by MACE alone. This warranted comparison of the diagnostic potential of MACE matched against gastroscopy.

In the second trial of their series, Rey and colleagues assessed the diagnostic ability of MACE [Rey *et al.* 2012]. In this blinded comparative trial, 61 patients presenting for gastroscopy underwent MACE 24 hours later. The same Olympus/Siemens system was examined with MACE physicians blinded to the outcomes of the preceding OGD. Visualization of major stomach landmarks was 88.5%, 86.9%, 93.4%, 85.2% and 88.5% for the gastric pylorus, antrum, body, fundus and cardia, respectively. Incomplete mucosal views were secondary to resistant excess mucus in seven patients. A further two patients had obstructed views because of excessive gastric motility and four patients due to rapid transpyloric capsule exiting.

Of the total of 108 pathological findings identified 63 were identified by both endoscopic modalities (58.3% concordance). Interestingly while MACE failed to identify 14 lesions only seen at gastroscopy, it unexpectedly isolated an additional 31 lesions which gastroscopy failed to detect. This could have been secondary to the extended duration of MACE compared to gastroscopy, where mean examination times were 17.4 minutes *versus* 5.3 minutes respectively. Despite the time discrepancy, MACE was universally more favourable to patients compared with gastroscopy. Furthermore, additional lesions identified only by MACE were minute and of inflammatory or erosive nature. A limitation to the study was that MACE closely followed after gastroscopy. It is thus conceivable that gastroscopy induced minor trauma which was then misinterpreted as primary pathology at MACE. Moreover, 31 patients underwent biopsy for *Helicobacter pylori* assessment and sites from biopsies again could have been overestimated during MACE assessment.

The authors communicated the importance of patient positional changes to facilitate capsule navigation which could not be achieved by magnetic steering alone. Here again, visualizing the fundus and cardia remained a challenge in its collapsed state. In addition, strong retrograde and anterograde gastric contractions also impeded antral and pyloric views in a few cases; the magnetic force was incapable of overcoming physiological peristalsis.

In the final part of this trilogy, Denzer and colleagues recently published a blinded prospective trial [Denzer *et al.* 2015]. A total of 189 patients were recruited into this follow-up multicentre study and modifications to the previous protocol were undertaken to resolve drawbacks. This included MACE examination before gastroscopy, and the ingestion of simethicone to optimize preparation of gastric contents. Lesions in this study were classified as major (requiring biopsy or removal) or minor. Of the 23 major lesions identified, specificity of MACE was 94.1% with a sensitivity of 61.9%. Interestingly, luminal visibility and location of the lesion had no impact on diagnostic accuracy. The specificity and sensitivity for minor lesions was 70% and 89%, respectively; in this case diagnostic accuracy was related to visibility and lesion location. True to the prequels of this study series, all patients preferred MACE over gastroscopy.

Robotic-arm magnetic manipulation: ANKON

In parallel to the studies ongoing in France, ANKON Technologies Co. Ltd first exhibited their prototype MACE system in Shanghai, China. In 2012, Liao and colleagues demonstrated the feasibility and safety of the system on 34 healthy volunteers [Liao *et al.* 2012]. The ANKON system consists of a capsule endoscope containing a permanent magnet and a single image CMOS sensor. This differs to the Olympus capsule described above, which inherits dual image sensing. The guidance system also differs in that it consists of a robot of the C-arm type with an implanted permanent magnet (Figure 3). Real-time capsule views are available to the examining physician and the capsule is navigated by the robot either through joystick control or left on automatic mode. The latter guides the capsule in a linear trajectory with rotational movements in an automated fashion. Subjects in this study remained static in the supine position for the duration of the examination. Preparation for the procedure involved ingestion of 1005 ml of water with air-producing powder which would subsequently release 540 ml of carbon dioxide for gastric distension.

Mucosal views of the gastric, cardia, fundus, body, angulus, antrum and pylorus were reported as 82.4%, 85.3%, 100%, 100%, 100% and 100%, respectively. This complements the challenges of proximal stomach visualisation in the aforementioned studies above [Denzer *et al.* 2015; Rahman *et al.* 2015c; Rey *et al.* 2010, 2012]. Opaque gastric fluid obstructed views in six volunteers in the most gravity-dependent part of the stomach, with no significant improvement in four subjects despite additional water ingestion. Average examination time was 43.8 minutes and thus significantly longer than that reported by previous authors [Rey *et al.* 2012]. In 14.6% of subjects magnetic steering towards the fundus and cardia was not achievable. This impacted on the ability to adequately visualise the entire gastric mucosa; as did opaque fluid and early transpyloric exiting of the capsule in one case each. Only one subject in the study reported abdominal discomfort from the gas-producing powder, the remainder experiencing no discomfort at all.

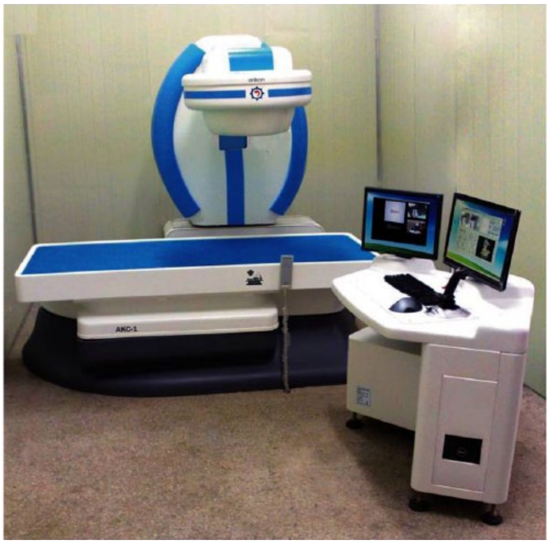

Figure 3. The Ankon magnetic navigation system.

Recently Zou and colleagues have further examined the diagnostic accuracy of the ANKON system against conventional OGD [Zou *et al.* 2015]. A total of 68 patients necessitating upper gastrointestinal endoscopic evaluation underwent MACE followed by gastroscopy, 4–24 hours later. The mean time for MACE examination was 29.1 minutes, in contrast to 8.5 minutes for gastroscopy. Of note, the protocol dictated that a minimum of 22 endoscopic photos were taken during gastroscopy for each patient. Of the 68 pathological findings detected, 53 were agreed upon by both endoscopic modalities. Gastroscopy detected an additional seven lesions not seen at MACE: three erosions, two ulcers, one atrophy and one mucous protuberance. MACE detected an additional eight lesions missed by gastroscopy: six erosions, one polyp and one mucous protuberance. Two patients experienced self-terminating abdominal pain. The authors also compared the ability of MACE and gastroscopy to determine whether gastric mucosa appeared normal or abnormal overall. The overall agreement was 91.2%, with a McNemar test p-value of 0.687, i.e. there was no significant difference between the two modalities.

In this study, mucus obstructing views was dislodged by rubbing the capsule lens against the gastric mucosa with rotational or translocation movements. However, three patients still experienced gastric navigation impairment secondary to inadequate gastric preparation. Patient satisfaction was not directly compared between both modalities, but reported adverse reactions were uncommon. Two patients reported transient, self-resolving abdominal pain a day after the procedure. One further patient experienced chronic diarrhoea where subsequent colonoscopy found the capsule endoscope at the ileo-caecum.

Challenges of the future

As attractive as MACE is conceptually, it must in reality prove its worth against what is already well established as the gold standard tool for upper gastrointestinal endoscopic investigation, gastroscopy. This necessitates overcoming several barriers to achieve true diagnostic ability and three main recurring themes extend across all studies to date; gastric preparation, visualization in the proximal stomach and adjusting for peristalsis.

Gastric preparation

Despite fasting, mucus and residual gastric debris obscures MACE views and interferes with mucosal assessment [Keller *et al.* 2011; Rey *et al.* 2012; Zou *et al.* 2015]. A variety of methods have already been employed during MACE. Agents such as simethicone have been used for its gastric cleansing and antifoam properties in isolation [Denzer *et al*. 2015] or in combination with pronase for additional mucolytic effect [Rahman *et al.* 2015c]. Interestingly, in Japan, where early gastric cancer accounts for 40–60% of all gastric cancers, visibility during gastroscopy must be at its highest quality and therefore there has been much effort to eliminate gastric mucus [Lee *et al.* 2012]. In view of this, various combinations involving combinations of simethicone [Neale *et al.* 2013], pronase [Chang *et al.* 2007; Lee *et al.* 2012], N-acetylcysteine [Neale *et al.* 2013] and dimethylpolysiloxane [Asl and Sivandzadeh, 2011] have been tested within the realm of gastroscopy and demonstrated effective gastric preparation. Thus, there will be value in any forthcoming comparative studies between available agents to ascertain the prime cocktail of gastric cleansing agents.

The proximal stomach

MACE consistently performs unimpressively in attempting to visualize the fundus and cardia in comparison with distal stomach counterparts [Rahman *et al.* 2015c; Zou *et al.* 2015]. In contrast to that found during gastroscopy, the proximal stomach remains collapsed during MACE. This natural anatomical state negates any effort to visualize the mucosa. Furthermore, as we are accustomed to distended views during gastroscopy, the appearance of a collapsed fundus is foreign and can potentially be misconstrued as the antrum. This may account for under-reporting of adequate fundal views [Rey *et al.* 2012] and at least in part explains the struggle for complete gastric mucosal assessment. Moreover, spatial orientation is straightforward during gastroscopy with forward views of the antrum and retroflexed views to approach the fundus and cardia. This is not the case with MACE. With this in mind, dual image sensors may perhaps assist in triangulating anatomical orientation as it relays information from opposite directions [Rey *et al.* 2010]; thus facilitating differentiation between proximal and distal gastric views. The added advantage would also be to potentially capture retrograde views of the fundus and cardia during forward capsule transit. Attempts to achieve distended views have included air-producing powder, but previous groups reported suboptimal visualization despite distending the stomach with carbon dioxide [Keller *et al.* 2011; Liao *et al.* 2012; Zou *et al.* 2015].

Utilizing CT modelling, Rahman and colleagues reported that the distance between the ventral skin surface and the fundus may be more than 20 cm in up to 20% of cases [Rahman *et al.* 2015b]. This would additionally explain the difficulty of magnetic capsule manipulation in this region, given that magnetic strength exponentially decreases with distance. The antrum however has a relatively shorter distance and perhaps this would also explain the difficulty with proximal views thus far. Further studies are needed to determine the most effective yet safe magnetic strength needed to manipulate a capsule endoscope in this region. Liao and colleagues have also postulated that positional change may in itself bring about improved views in the proximal stomach independent to magnetic steering [Liao *et al.* 2012]. This was based on comparison between their study where patients lay stationary in a supine position compared with multiple positional changes reported by other groups [Rey *et al.* 2010, 2012; Denzer *et al.* 2015]. However, this hypothesis is yet to be tested. Of course an alternative to moving the capsule closer to the mucosa for assessment is to augment capsule illumination and depth of view by the capsule image sensors and it is expected that capsule performance specifications will continue to excel in the near future.

Peristalsis

It would seem that peristalsis, particularly at the antrum, restricts full magnetic control over capsule endoscopy. This is particularly the case when incomplete gastric examination is due to rapid pyloric expulsion of the capsule [Keller *et al.* 2011; Liao *et al.* 2012; Rey *et al.* 2012] or when contractions repeatedly push the capsule backwards and preclude adequate antral views [Rey *et al.* 2012]. Antispasmodics such as hyoscine butylbromide are routinely used during gastroscopy in Japan, influenced by the higher prevalence of gastric cancer and their national screening programme to detect early gastric cancers [Yao, 2013]. Creating an environment that harvests high diagnostic sensitivity is therefore crucial; reducing peristalsis can facilitate this. Recently there has been encouragement towards similar practice in the United Kingdom [Veitch *et al.* 2015]. Attractively, recent studies suggest that peppermint oil is equally as efficacious as hyoscine butylbromide in achieving this antiperistaltic effect [Hiki *et al.* 2003, 2012; Imagawa *et al.* 2012]. With no reported side-effects and the ability to avoid intravenous cannulation or intramuscular injection, this is an avenue of much interest to pursue. Antispasmodic use during MACE has not yet been reported. Nevertheless there is clearly a role to translate what we already know is effective in gastroscopy to MACE, where peristalsis has proven troublesome.

The true potential of MACE

Capsule endoscopy is indeed established as the investigative gold standard for the small bowel territory. However, there is understandably still scepticism regarding the true potential of MACE in the upper gastrointestinal tract. Although studies to date have hinted at effective diagnostic potential, they have concomitantly highlighted unresolved limitations. Nonetheless as described in this article, these limitations are finite and solutions achievable. Moreover, hesitancy to invest in MACE has traditionally been ascribed to the lack of therapeutic or biopsy capability. To this two points are worth mentioning. First, even with only pure diagnostic capabilities a minimally-invasive investigation alternative has potential to stratify patients and avoid gastroscopy for those who do not require biopsy or therapeutic intervention. This would potentially benefit countries with gastric cancer screening programmes the most by reducing the burden of gastroscopy requirement. Caprara *et al.* have already demonstrated the feasibility of a modified capsule endoscope in porcine models for this purpose, with low financial implication [Caprara *et al.* 2014]. In addition, much research is already *en route* with developing capsules with therapeutic dexterity. These include biopsy and targeted drug therapy delivery but at present these remain in the preclinical development stage [Koulaouzidis *et al.* 2015].

In conclusion, MACE remains in an early stage of development and further large scale studies are needed to validate its value in the upper gastrointestinal tract. However, advances in technology can occur rapidly: within 15 years capsule endoscopy has been introduced, established as the gold standard for small bowel investigation and is now gaining reputation in the oesophagus, stomach and colon [Slawinski *et al.* 2015; Spada *et al.* 2015]. We believe that the limit of MACE is yet to be discovered. However, it is likely that technological developments will continue with momentum and it is not inconceivable that MACE may match, if not transcend gastroscopy in the future.

At the advent of capsule endoscopy, many authors have quoted the 1966 movie *The Fantastic Voyage* to express the fascination with a novel way to internally investigate the gastrointestinal tract [Swain, 2008]. With the innovative advances already achieved in capsule endoscopy and the promising possibilities of MACE in the 21st century, perhaps it is now more fitting to quote a more recent movie, such as *Iron Man 2*. In the sequel to the first blockbuster, Tony Stark's (Iron Man) father, Howard Stark, leaves him a message through a cine film recording with much confidence in his son: 'This is the key to the future. I'm limited by the technology of my time, but one day you'll figure this out. And when you do, you will change the world'. Indeed upper gastrointestinal capsule endoscopy may also be limited by current technological availabilities but may one day change the way we practice gastroenterology completely.

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Conflict of interest statement

The authors declare that there is no conflict of interest.

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